

**The Effects of Human Interactions on the**  
**Population of Wild Spinner Dolphins, *Stenella longirostris*,**  
**off the Waianae Coast of Oahu**

Final Report

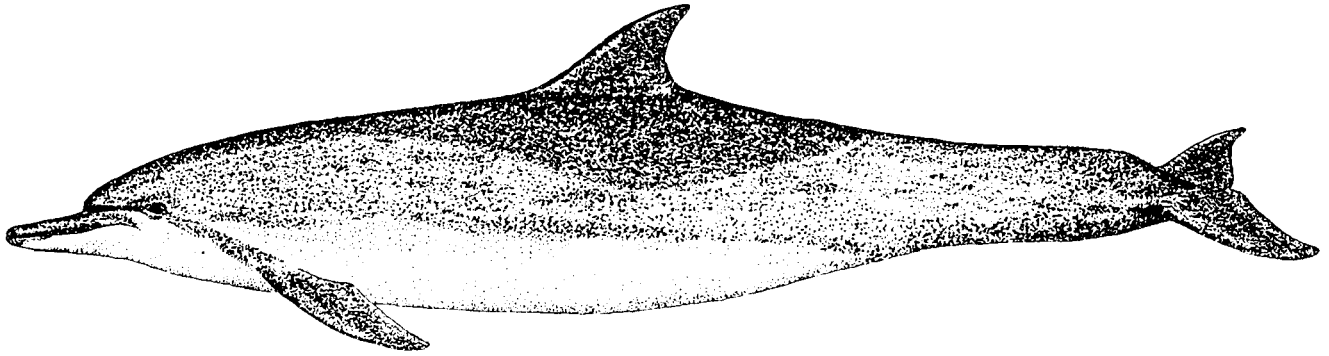
December 16, 1997

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Class Mammalia — The Mammals  
Order Cetacea — The Whales  
Suborder Odontoceti — The Toothed Whales  
Family Delphinidae — The Ocean Dolphins and Porpoises

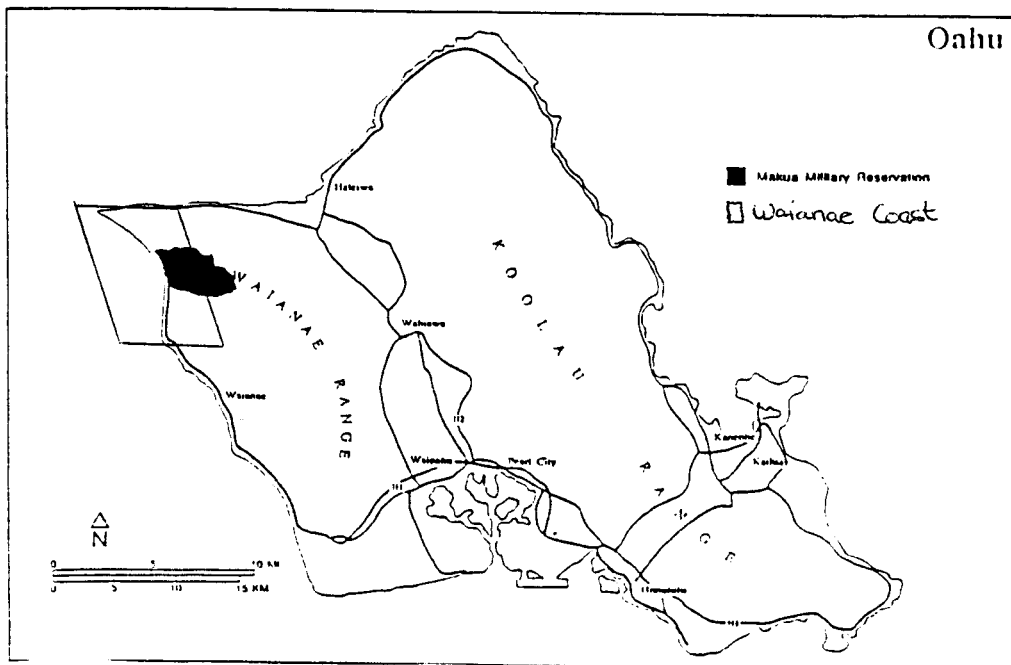


### THE SPINNING DOLPHIN

Also known as the Long-snouted Dolphin  
*Stenella longirostris* (Gray, 1828)

The Hawaiian spinner dolphin, *Stenella longirostris*.

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The Waianae coast of Oahu, Hawaii.

## **Abstract**

*The current trend towards environmental awareness is accompanied by people seeking ways to change their relationship with nature. Swimming with dolphins is one such activity that is on the rise worldwide and with it is a growing concern for the impacts that humans may be placing on the dolphins' well being. The Hawaiian spinner dolphin, *Stenella longirostris*, is known to rest in the shallow, sandy bottomed, near shore waters off of the island coasts. Their close proximity to shore, coupled with their slow and peaceful movements while resting, make them particularly vulnerable to anyone who wishes to pursue a close encounter with them. One such rest cove exists on the west shore of Oahu. With an increasing number of visitors and eco-tours to this area, there is a growing concern that this ecosystem may be overwhelmed and that the dolphins may be forced out of their resting habitat. Baseline data have been collected on human-dolphin interactions at this location over the past three summers. Results from this study show a decrease in the group size of dolphins using this area from 1995 (mean=72 individuals) to 1996 (mean=58 individuals) to 1997 (mean=29 individuals); along with a decrease in the amount of time spent in this area from 1995 (mean=4 hours, 3 minutes) to 1996 (mean=2 hours, 36 minutes) to 1997 (mean=2 hours, 5 minutes). These observations suggest that something is disrupting this habitat. There are few rest areas along the Oahu coasts, and the loss of this habitat could prove to be detrimental to the spinner population.*

## **Introduction**

The spinner dolphin (*Stenella longirostris*) is so commonly named for its extraordinary display of aerial behavior. Residing in the tropical and subtropical waters of the Atlantic, Indian, and Pacific oceans, spinners are known to burst from the water at top speed and rapidly rotate about their longitudinal axis for as many as four revolutions before falling back into the sea (Norris et al., 1994).

Hawaiian spinner dolphin schools are found throughout the island chain from Kure Atoll in the northwest, to the southern tip of Hawaii island. Norris et al. (1994) extensively documented the daily life cycle of the spinner dolphins at Kealahou Bay, on the island of Hawaii, revealing a predictable behavioral pattern of resting and socializing in near shore waters by day and feeding upon deep-scattering layer fishes, squid, and shrimp by night. Ostman (1994) speculates that the foraging strategy on this clumped, abundant prey along with predation pressure from sharks, lead spinner dolphins to form small core groups which coalesce to form the larger feeding groups. There is fluidity within the entire school and stability within core groups.

## **Human-dolphin interactions**

The current trend towards environmental awareness is accompanied by people seeking ways to change their relationship with nature (Simonds, 1991). Swimming with dolphins is one such activity that is on the rise worldwide, and is accompanied by a growing concern for the impacts that humans may be placing on the dolphins' well being. While some people describe their wild dolphin encounters as "mystical", "spiritual", or even "therapeutic", and feel that the dolphins "enjoy" swimming with them (Simonds, 1991); others feel an increase in numbers of people pursuing these close interactions is likely to disturb the animals' natural behavioral patterns and could prove to be detrimental to their complex social structures (Wursig, 1996).

Wild dolphins are highly gregarious mammals, which spend their lives moving in and out of schools based on complex social structures (Norris and Dohl, 1980a and Norris et al., 1994). Resting spinner dolphins form small, highly aggregated groups during the day and then may merge into larger feeding groups at night (Norris and Dohl, 1980b). Such a diversity in social integration requires the use of highly developed communication systems. The disturbance of a single animal is quickly transmitted throughout the school causing the animals to react as a whole, often times fragmenting the school into subschools that may or may not rejoin once the initial disturbance has passed (Norris and Dohl, 1980b). These disturbances may be brought on by a variety of factors both natural, such as a nearby predator, or anthropogenic, such as the presence of boats and swimmers in rest coves.

Human-dolphin interactions have been recorded throughout history dating back to the early Greek civilization (Quayle, 1988). Recent studies have documented interactions between humans and dolphins in organized swim-with-dolphin programs in the United States (Samuels and Spradlin, 1995) and New Zealand (Constantine and Baker, 1996). These studies concluded that programs with dolphins in captive situations had higher incidences of aggressive and sexual behaviors towards swimmers when the dolphins were not directly controlled by their trainers. Some dolphins in this situation were also noted as displaying a submissive behavior toward swimmers, which may have been an expression of avoidance (Samuels and Spradlin, 1995). In New Zealand, swim-with-dolphin

programs are operated in natural settings. Constantine and Baker (1995) noted the behavior of dolphins, when approached by boats or swimmers, varied depending on the species. Common dolphins (*Delphinus delphis*) not only avoided or ignored swimmers more often than bottlenose dolphins (*Tursiops truncatus*), but they also exhibited a higher percentage of behavioral changes than bottlenose dolphins when approached by tour boats.

In Hawaii there is only one organized swim-with-dolphins program, located on the Big Island, in which bottlenose dolphins are kept in a captive situation. While there are institutes that house Hawaiian spinner dolphins, such as Sea Life Park on Oahu, there are no organized swim programs that allow humans to interact with these captive dolphins; however, the spinners are known to rest in the sandy bottomed shallows of near shore waters off of the island coasts. Their close proximity to shore as well as their slow, peaceful movements while resting, make them extremely vulnerable to anyone seeking an up-close experience with them. On the Waianae coast of Oahu one such rest cove is known to exist and is receiving an increase in visitor traffic. Aside from the residents that utilize this site for fishing and recreation, both small and large tour operations have become more prominent. Small tour operators bring individuals to kayak and swim with the resting dolphins, while the presence of large dolphin-watching tour boats have become more regular. Although the spinner dolphin is protected under the Marine Mammal Protection Act which prohibits “any intentional or negligent act which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns” (Danil, 1995); there currently is no enforcement of these rules and regulations at the rest site of this study. With an increase in numbers of people visiting this area comes a greater possibility of altering the dolphins’ natural behaviors, as well as forcing them out of this essential habitat. Very few rest areas exist along the Oahu coasts, and the loss of this habitat could prove to be detrimental to the spinner population. If the dolphins are forced to leave this area, it is questionable whether other resting sites could support the additional numbers of dolphins (Danil, 1995).

## **Goal**

The purpose of this study was to evaluate baseline data collected over the past three years on human-dolphin interactions at a known rest site for the Hawaiian spinner dolphin, *Stenella longirostris*, on the island of Oahu. This study was designed to determine what, if any, kinds of impacts humans are placing on the dolphins using this area. This goal was accomplished by looking for changes in the dolphins' population structures, behavioral patterns, and lengths of stay at this rest site over the past three years.

## **Methods**

### **I. Data collection**

Land-based observational data were collected during the summer months of 1995, 1996, and 1997 (Table 1). These dates include the "peak" tourist visitation days and times for this location.

<b>Dates</b>	<b>Times</b>	<b>Days of week</b>	<b>Total observational days</b>	<b>Total observational hours</b>
<b>1997:</b> July 15 - August 31	6 am -12 pm	Tues, Sat, Sun	21 days	126 hours
<b>1996 :</b> August 1 - August 30	6 am - 6 pm	Mon - Sun	30 days	360 hours total *180 hours were used for this study
<b>1995:</b> July 1 - August 28	6 am - 6 pm	Mon - Sun	59 days	708 hours total *354 hours were used for this study

Table 1. Study dates and times.

During the above mentioned times, a weather and bay activity log were maintained by following the specific guidelines as described in Appendix A. Observational data were collected via binoculars and recorded every 15 minutes. The total number of swimmers, kayakers, and the estimated group size of dolphins in the study area were recorded, as well as three consecutive dive times of a specific, individual dolphin. The group size of dolphins was determined by counting the maximum number of dolphins that surfaced at one time, then doubling this number. This number was then

recorded by range (in bins of 25) into which it fit, i.e. 1-25, 26-50, 51-75, etc. Every half an hour, the total amount of aerial behaviors exhibited by a group of dolphins were recorded for a five minute time period. The aerial behaviors recorded followed the definitions set by Norris, et al. (1994), during their studies of the spinner dolphins at Kealahou Bay, on the Big Island of Hawaii (Appendix B).

Observational data for the 1995 and 1996 field seasons were collected every day of the week, for 12 hours a day; whereas field data for 1997 were collected 3 days a week for 6 hours a day. Justification for these differences was based upon observations compiled from the 1995 and 1996 field data. There was a distinct difference in the number of people utilizing the study area during the week as compared with those on the weekend. Hence, it was determined that essential data only needed to be collected on a day of low-use (Tuesday) and compared to those of high-use (Saturday and Sunday). Secondly, the reduction in observational time was based on the fact that the dolphins occupied the study area with a greater frequency in the morning than afternoon hours.

\*For purposes of this study, only data collected fitting the format of that in 1997 were selected and utilized (see Table 1).

## II. Raw data review

Field data for 1997 were collected by three different teams of individuals over the summer. Data sheets, therefore, needed to be compiled and reviewed for consistency among the three teams. Any discrepancies in the data were addressed and clarified during this time.

## III. Database design

An Excel® database template was designed for use with a Power Macintosh model computer, and all necessary data were entered. The following values were determined for each study day.

- Average number of swimmers present in study area over the entire day.
- Maximum number of swimmers in the water at one time.
- Average number of dolphins present over the entire day (based upon midpoints of estimated group size, i.e. estimated number of dolphins is 1-25, then midpoint is 13).

- Average dive times (based on three sequential intervals) of dolphins for each applicable 15 minute time period.
- Total amount of time spent by dolphins both within and outside, visible but out of range (VOR), of the study area.
- Frequencies of aerial activity (spins, slaps, and leaps) per dolphin, for each applicable 30 minute time period.

#### IV. Literature review

Literature pertaining to human-dolphin interactions was reviewed to determine if previous studies had noted specific behavioral modifications, illnesses, or other potential impacts that dolphins have been exposed to as a result of human contact. Documents reviewed include books, journal articles, graduate theses, and dissertations. Findings from these documents were used as a guide in the determination of data points to be analyzed for this study.

#### V. Data analysis

Using bay activity log information provided by Earthtrust, the following list of values were plotted over time.

- Frequency of dolphin group sizes for 1995, 1996, and 1997.
- Frequency of time spent by dolphins in study area for 1995, 1996, and 1997.
- Frequency of swimmer group size for 1995, 1996, and 1997.

The means and standard deviations were calculated for each of the above listed frequencies.

#### **Results**

The group size of dolphins using the waters of this rest site ranged from 13-200 individuals in 1995 with a mean and standard deviation of  $72 \pm 27$  (n=1165); 13-150 individuals were observed in 1996, with a mean and standard deviation of  $58 \pm 24$  (n=309); and 13-75 individuals in 1997,  $29 \pm 20$  (n=220). A dolphin group size composed of 51-75 individuals was the most common in 1995 (observed 39% of the time) and 1996 (observed 38% of the time), while a group size of 1-25 was most common in 1997 (observed 47% of the time) (Figure 1).



The amount of time the spinner dolphins spent in the study area per day ranged from 0-5+ hours in 1995 with a mean and standard deviation of 4 hours, 3 minutes  $\pm$  1 hour, 28 minutes (n=48); 0-5 hours in 1996 with a mean and standard deviation of 2 hours, 36 minutes  $\pm$  1 hour, 24 minutes (n=27); and 0-5+ hours in 1997 with a mean and standard deviation of 2 hours, 5 minutes  $\pm$  1 hour, 40 minutes (n=21). The dolphins most commonly spent 5+ hours within the study area in 1995, with the frequency of this occurrence being 29% of the time; 3 to 4 hours were most commonly seen in 1996, with the frequency of occurrence being 30%; and in 1997 the dolphins most commonly spent less than one hour within the study area, with the frequency of occurrence being 33% of the time (Figure 2).

The total number of swimmers in the study area ranged from 0-63 individuals in the 1995 field season, with a mean and standard deviation of  $10.4 \pm 8.9$  (n=837); 0-51 individuals in the 1996 field season, with a mean and standard deviation of  $11.6 \pm 10.8$  (n=344); and 0- 41 in the 1997 field season, with a mean and standard deviation of  $8.7 \pm 7.2$  (n=385). The most common group size of swimmers for all three years fell into the 0-10 category. This group size was observed 61% of the time in both 1995 and 1996, with an increase to 71% in 1997 (Figure 3).

## **Discussion**

While the amount of smaller group sizes of swimmers increased by 10% in 1997, the mean number of swimmers had slightly decreased compared to the other years (Fig. 3). This may be directly related to the decrease in dolphin numbers in the area. Possibly more important than the actual numbers of people visiting this area are the types of people. In the advent of eco-tourism, Duffus and Dearden (1990) have classified three levels of personality types taking part in this form of tourism. They classify the Level I visitors as “wildlife specialists”. In general these visitors are ecologically aware and knowledgeable of the area in which they are visiting, and usually require little management intervention. They respond to the area respectfully, leaving little to no impact on the social and ecological systems of the site. The Level II visitor is described as “a less ambitious user”. These are people who’s knowledge and respect of the area is

less inspired than that of the Level I visitor. Level III is reached when general tourists with little interest in the site's attraction are the most common visitor. At this point, Duffus and Deaden (1990) state, the "host society and ecosystem are probably stressed and will require a large amount of management intervention". With both small and large tour operations becoming more and more prominent to this site, the visitor type is now believed to be between Level II and Level III. This is supported by incidental observations made by research team members, which found many of the tourists to this area are either weak swimmers, or don't even know how to swim at all. Groups of tourists have been observed floating in the water wearing life jackets, seemingly without any previous knowledge of sea conditions or currents to this area (Danil, 1995). For others, it was questionable if they have even had previous experience in oceanic waters at all. It is evident that many of the tourists lack knowledge of the area's ecological significance. Many of the visitors are not even aware of the fact that the dolphins are coming into shore to rest, not out of curiosity for the people who have gathered there to try to swim with them. The extent of their knowledge does not usually go beyond the belief that they are going to swim with the dolphins, play with the dolphins, touch the dolphins, and many even believe that if they are lucky enough they will be able to actually "ride" a dolphin. Along with this type of visitor often comes the mentality that if the dolphins don't like it that I am here, then the dolphins can simply leave and move on to another area. Unfortunately, this is not the case. The dolphins really don't have any other place to go.

There are three influential characteristics that constitute a rest site for spinner dolphins. First, the location must be shallow and have a sandy bottom. This is thought to offer a protective foundation for the resting spinners. Natural predators, such as sharks, are more readily seen against the light, sandy bottom than they are against dark coral heads and rocky shores. Second, the area must have clean and clear water. Norris et al. (1994) documented that the spinners all but cease the use of their sonar sensory system when coming into rest. It is believed that the dolphins utilize their sonar extensively during their nightly feeding bouts and relax this system during the day. Thus by day, the dolphins rely more heavily on the use of their other senses such as sight. Clean and clear water would therefore be a necessity for seeing the other members of their group and for

detecting predators. Third, the rest area must be in close proximity to the dolphins' feeding habitat. The dolphins expend a large amount of energy during their nightly feeding bouts, making it necessary for them to be able to move into a rest area with ease in order to relax and refuel for the next nights' feeding ritual. The rest site on Oahu's west coast, in which this study was focused, provides areas that are adequate both for the spinners' feeding and resting grounds. The data presented in this paper however, suggests a decrease over time in both the group size of spinner dolphins, from a mean of 72 individuals in 1995 to a mean of 29 individuals in 1997 (Fig. 1), and in the amount of time they are spending at this site, from a mean of 4 hours, 3 minutes in 1995 to a mean of 2 hours, 5 minutes in 1997 (Fig. 2). Based on these factors it is subject for discussion that something is disrupting this essential habitat and forcing the dolphins to leave.

Whether the decrease in groups size of dolphins or length of stay of the dolphins to this particular rest site is a direct cause of the numbers and types of people visiting this area can not, at this point, be clearly said. There are many other factors that need to be evaluated such as weather and environmental conditions, military activity from the nearby military reservation, and an increase in tour boat traffic to the area, just to name a few. It should also be noted at this time that the results presented in this paper are regarded as preliminary, in that they have yet to be tested statistically for their significance.

It is evident though, that people wanting to interact with the wild dolphins must be educated on the ecology of this species and on appropriate behavior when near the dolphins. While it is not suggested that tours to this area be promoted, it is recommended that any tours that do come to the area be held responsible for the education of their patrons, and ensure that all visitors comply with the rules and regulations of the Marine Mammal Protection Act.

## **Conclusion**

It is important to continue the research presented in this paper to learn more about the spinner dolphins' natural behaviors. Before it can be determined why the dolphins are seemingly leaving this area and utilizing it less, or what types of activities, if any, are adversely affecting the dolphins, it is necessary to understand their daily behaviors and

life long needs. This type of information must be gathered now to secure protection for the dolphins in the future, before they leave this rest area for good.

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Figure 1

Group Size of Spinner Dolphins at Makua Beach  
Summer: 1995 - 1997, 6 am to Noon

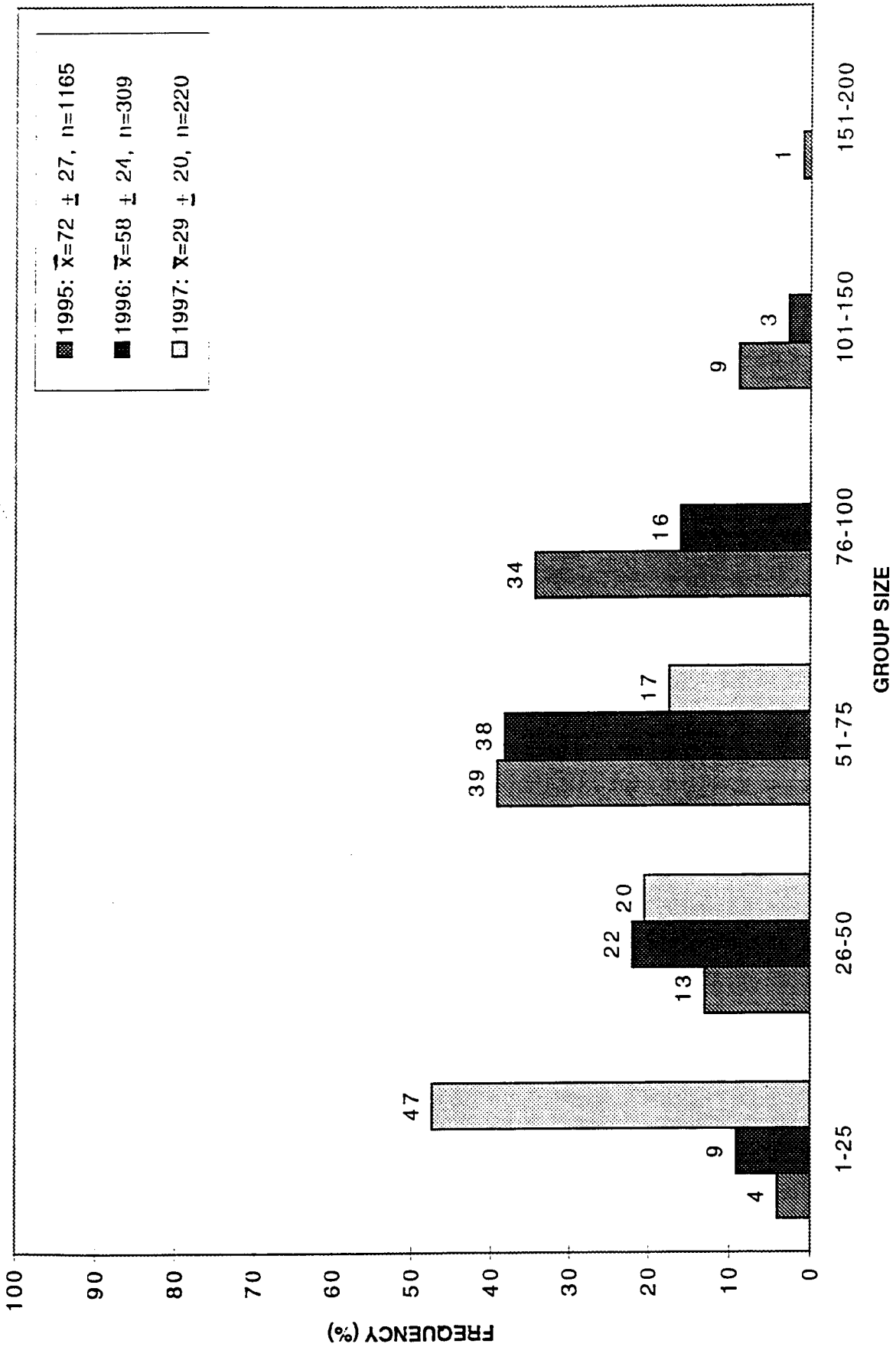


Figure 2

Cumulative Dolphin Time Spent at Makua Beach  
Summer: 1995 - 1997, 6 am to Noon

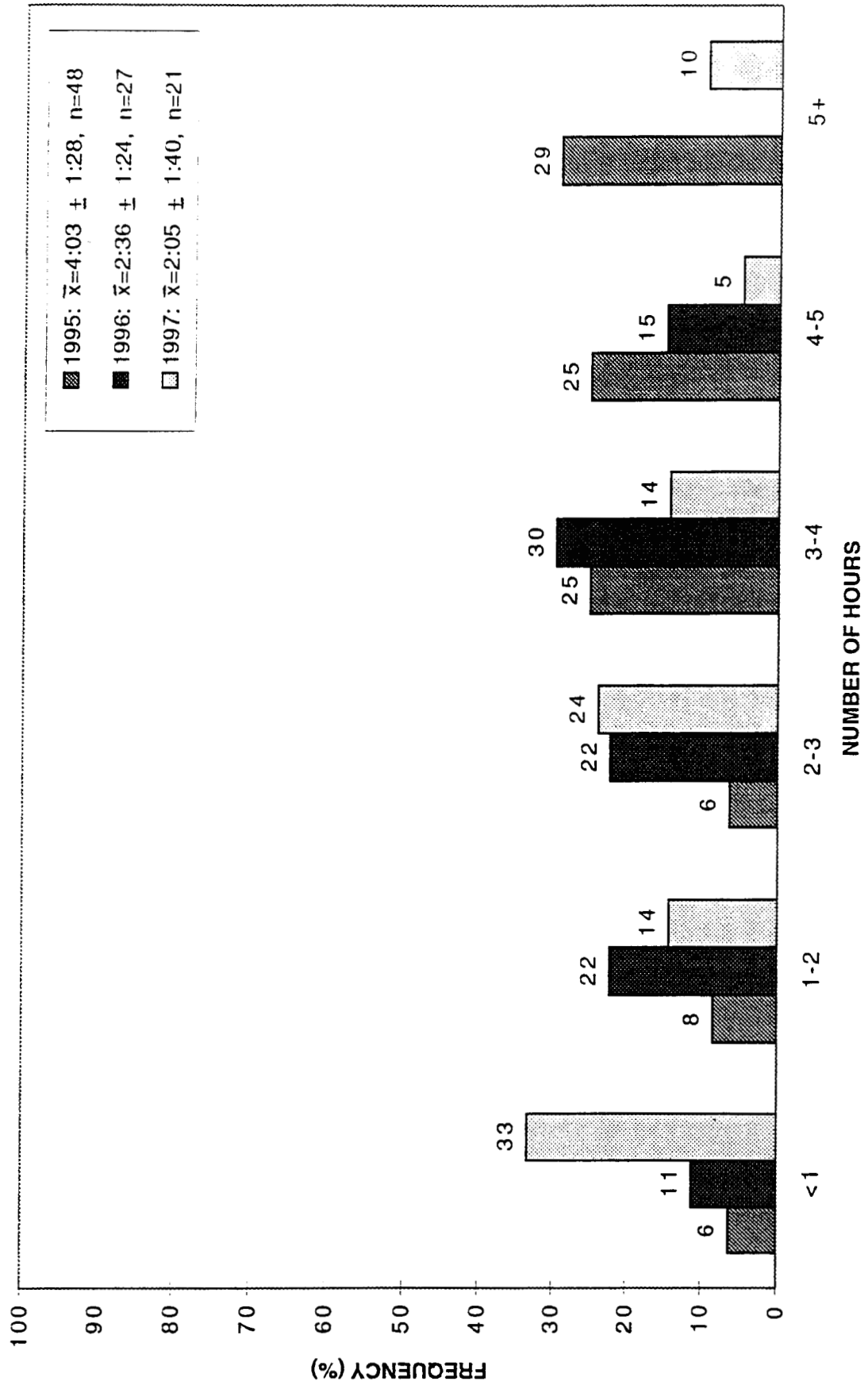
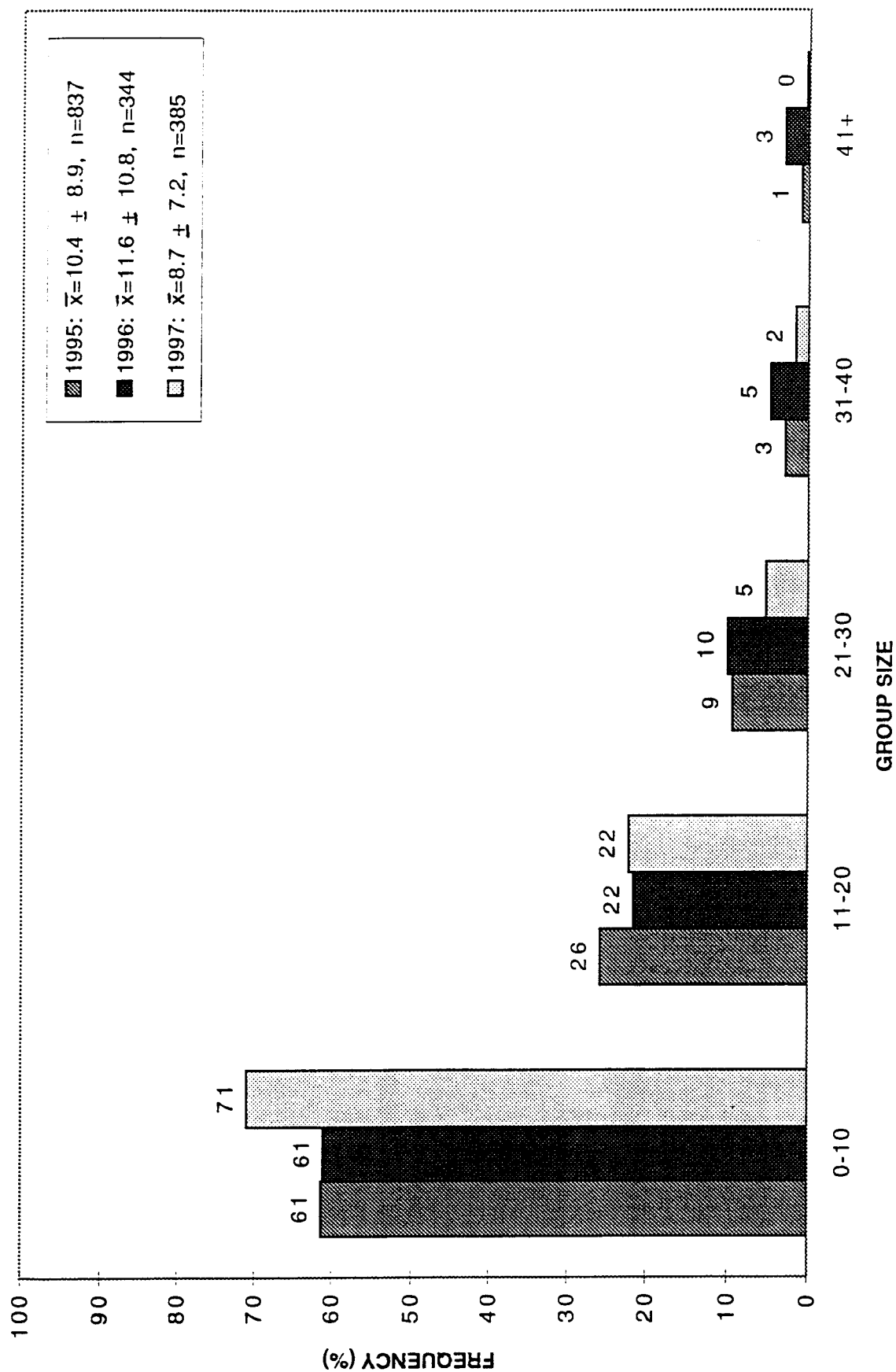


Figure 3

**Group Size of Swimmers at Makua Beach  
Summer: 1995 - 1997, 6 am to Noon**





# Appendix

## A

# 1997 WEATHER LOG

DATE \_\_\_\_\_

WATCH TIME	WIND DIRECTION	SEA STATE	CLOUD COVER
0600			

WATCH TIME	WIND DIRECTION	SEA STATE	CLOUD COVER
0800			

WATCH TIME	WIND DIRECTION	SEA STATE	CLOUD COVER
1000			

## 1997 BAY ACTIVITY LOG

**Observer:**

**DATE:**

[illegible]

## Guidelines for Taking Spinner Study Beach Data

### WEATHER LOG:

You will take basic weather conditions three times during your shift, at 0600, 0800, and 1000.

**Wind Direction:** face into the wind and use the compass

**Sea State:**

B0	surface like glass
B1	ripples on surface
B2	occasional white caps
B3	frequent white caps
B4	go home

**Cloud Cover:** this is the percentage of the sky that is covered by clouds.

Use the blank spaces to log the time and a description of anything unusual or noteworthy, such as:

- fishermen/ net activity
- boat traffic
- helicopter presence
- artillery/ bomb practice
- brush fires
- ash debris in air
- monk seal
- Marc Lammers UH research boat in bay
- any environmental change

### BAY ACTIVITY LOG:

#### Beach Data Parameters

Basic data is taken every 15 minutes from 0600 to 1200. The observer with the binoculars performs a scan looking for dolphins. Each scan consists of two slow sweeps across the area lasting 5-10 minutes.

**Date:** include the day of the week as well as the date of the month

**Observer:** mark who is filling out the log sheet and who is using binoculars to call intervals and aerial behavior

**SwmS:** number of swimmers, south side of bay

**SwmN:** number of swimmers, north side of bay

**NKyk:** total number of kayaks, combined north and south

**NDs:** estimated range of group size of dolphins, in bins of 25 (1-25, 25-50, 50-75, etc.); if no dolphins in range, enter "0"

**DLoc:** dolphin location, North or South; if they are spread across the bay, indicate by "N/S." Enter this value, if possible, even when ND's = 0 but the dolphins are visible in the distance

**VOR:** stands for "Visible but Out of Range" - enter a check here if the dolphins are not in the range of our data area (so NDs = 0), but are still visible in the distance

For dive intervals, one person follows the dolphin with the binoculars and calls start and stop times, while the other person runs the stopwatch. The timer is started when the dolphin takes a breath and dives, then stopped when it resurfaces. Usually the three intervals come in fast succession, so the stopwatch person must remember the number of seconds (rounded off) and write them down after the 3 intervals are finished.

**Int1:** dive duration in seconds, first interval  
**Int2:** second dive interval, see Int1  
**Int3:** third dive interval, see Int1

Aerial behavior is tallied every 30 minutes (on the hour and half hour, after the basic data has been taken) for a period of 5 minutes. Usually one person calls the jump types, the other person tallies the calls. If there is a large number of dolphins spread over a large area, the logsheet person may need to watch also. Best not to use binoculars for this, as it limits the field of view.

**Spins:** number of aerial spins during a 5 minute period; body must completely leave the water and make at least half a rotation  
**Slaps:** number of aerial slaps during a 5 minute period; includes tail slaps, head slaps, back slaps, and side slaps where the body only partially leaves the water; this category also includes undetermined aerial behavior which creates a splash  
**Leaps:** number of aerial leaps during a 5 minute period; the body must completely leave the water; includes tail over head leaps  
**Comments:** anything relevant, such as exact time of first dolphin sighting

#### GENERAL NOTES:

**Data Range:** The bay is divided into north (to the right as you face water) and south (to the left). The middle dividing line is the south edge of the big table rock on the beach. North and south borders are Hercules Rock (north, and Pray-for-Sex rock (south). The border parallel to the beach is subjective - it is as far out as one can comfortably see without binoculars, roughly a quarter or a third of a mile. If you could take dive intervals without using binoculars, they are in range. Take dolphin data when the dolphins are within in the perimeters of these ranges; continue to take swimmer and kayak data even when the dolphins are outside the valid data range.

**Counting Dolphins:** Count the maximum at the surface at one time. Double this number, and then enter the appropriate range on the log sheet. So for example, using the binoculars I count roughly 30 dolphins surfacing at any one time. Double that is 60. The correct range to enter is 50-75 dolphins.

# **Appendix**

## **B**

nous than Melville's, as he traveled amidst a school of what were probably spinners off Honaunau, less than 10 km south of our Kealake'akua base camp (spinners are by far the most common dolphin in this inshore area).

... we dashed boldly into the midst of a school of huge, beastly porpoises engaged at the eternal game of arcing over a wave and disappearing, and then doing it over again and keeping it up—always circling over, in that way, like so many well-submerged wheels. But the porpoises wheeled themselves away and we were thrown upon our own resources.

By the twentieth century, scientists began to think more scientifically. Why do dolphins carry out aerial behavior? Why is it so ubiquitous? Why does it seem species specific? The first scientific analysis of spinning was done by Hester et al. (1963), who photographed spinner dolphins on the eastern tropical Pacific tuna grounds and traced body postures from a sequence of moving picture frames recorded during a single leap. The resulting diagram clearly showed the kinesics, or body movement, of a spin (see fig. 56). It showed how the dolphin, by twisting its neck and body while in air, is able to perform as many as about four rotations during a 1.25-sec leap that can take it about 2 m into the air. These authors tested the idea that spins might be used to dislodge remoras. They concluded that this could not be the complete explanation because spinning animals often do not carry such ectoparasitic fish. They also rejected courtship displays as an explanation because spins were performed by both immature and mature animals of both sexes, a point with which we concur. Even very small juveniles spin.

### CATEGORIES OF AERIAL BEHAVIOR

Norris and Dohl (1980a) analyzed spinner dolphin aerial behavior and concluded that there were at least seven aerial patterns exhibited by the species. All but one of these patterns, the arcuate leap (fig. 50), involved slapping the water upon reentry along with production of a boil of bubbles at the water surface and a plume underwater upon reentry. These classes of aerial behavior roughly arranged in increasing order of activity are nose-outs (and fluke-outs), tail slaps, back slaps, head slaps, arcuate leaps (and salmon leaps), tail-over-head leaps, and spins. Note that the salmon leap is a pattern seen only in very rapidly moving schools. It is possible to subdivide aerial behavior further and to erect more classes than we list here. But we think that such overclassification only serves to obscure the relationships observed.

The following analysis of spinning resulted from one cruise devoted solely to studying the aerial patterns of spinner dolphins, in which an at-

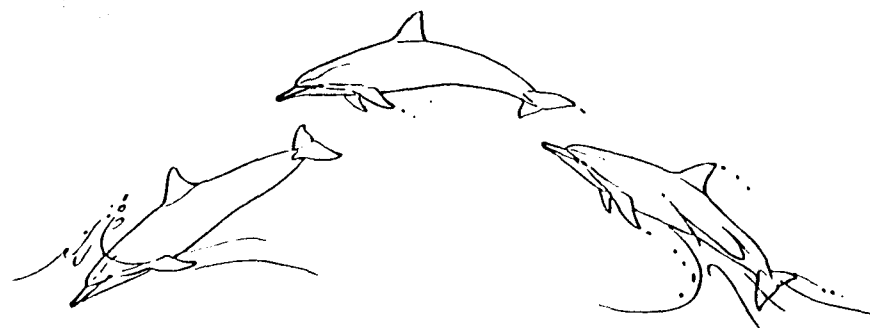


Figure 50. A spinner dolphin making an arcuate leap.

tempt was made to analyze the various behavior patterns themselves, their location of occurrence in schools, and the context of their occurrence. This concerted effort was followed by many separate observations of these aerial patterns at sea and finally by many hours of observation of a captive school in which we could dissect the occurrence of the patterns, the details of their performance, and their collateral effects (sounds produced or effects on the behavior of schoolmates). In time, the form and context of aerial behavior began to fall into predictable patterns, which are presented here.

Using the incidence of these various patterns at any given time, the surface observer can assess the activity state of a school (most simply, the speed of locomotion) with some accuracy. Since most social patterns seen in dolphin schools are related to activity state, the surface observer can make a modest assessment of expected events below the surface by quantifying the aerial patterns. For instance, the various patterns found among socializing dolphins are also ordered in relationship to activity state, as is the level and kind of vocalization.

The daily pattern of movement and school state also correlate closely with the details of aerial activity. Typically, aerial activity was seen with high frequency in open water outside Kealake'akua Bay as dolphins swam into the cove in the morning. Once schools came in past the inner headlands of the bay (Manini Point), aerial activity subsided rapidly. It was seldom seen during the rest period unless some event, such as the passing of a tour boat or a water skier, caused a brief flurry of surface activity. In the late afternoon, the dolphins became active again, and aerial patterns were often abruptly evident, marking the cessation of the rest period with some precision (fig. 26). Once rest was ended, the dolphins generally increased their surface activity until it reached a high point about 10 hr after initial entry into the bay (table 3). Those groups that stayed in the bay for a briefer period than average tended to con-

TABLE 3 Frequency of Aerial Activities Seen in Kealake'akua Bay\*

Aerial Activity	Frequency (Animals per hr)	Peaks of Activity
Nose-outs	0.072	Morning
Tail slaps	0.240	Morning/afternoon
Flips	0.240	Morning/afternoon
Head slaps	0.240	Morning/afternoon
Salmon Leaps	0.360	Afternoon
Side and Back slaps	0.480	Afternoon
Spins	0.600	Several peaks throughout the day

\*Data are standardized by animals per hour. Most peaks were diurnally bimodal, with one peak in the morning and one in the afternoon. Peaks of activity more than two times as high as other daily peaks were scored for just that high part of the day, while peaks closer together were scored for both morning and afternoon. Arcuate leaps were infrequently seen and are not included.

dense this pattern, but when such records were averaged, they also showed the least amount of aerial activity during the approximate midpoint of their stay.

Our process in selecting the eight patterns described here was first to watch the dolphins for a long period, attempting to gain a "gestalt" of the entire process, and then to let the real modal patterns emerge in our minds, rather than to catalogue immediately how many classes it was possible to erect. This point is not trivial since behavioral literature is rife with long lists of subdivided behavior, often divided so finely that functions are lost in the "noise." For example, this is commonly done by those who create "ethograms" for a given species. At any rate, the following descriptions are of aerial patterns that we saw being produced by many different animals again and again.

## NOSE-OUTS AND FLUKE-OUTS

### Nose-Outs

The earliest indication of arousal in a resting school is often given by one or two dolphins thrusting their rostra from the water as they move slowly at the surface. We call this a *nose-out*. Sometimes the snout is splashed back against the surface as the animal snaps its head downward. On one occasion, three dolphins were seen slowly "sparring" with nearly vertical rostra. The behavior lasted for an estimated 7 sec.

Nose-outs (along with fluke-outs) are the lowest activity level aerial pattern in our list (fig. 51). They are frequently seen among quietly socializing animals just before or after the rest period. Their appearance at



Figure 51. A spinner dolphin side-slapping in a school in which nose-outs are especially evident. Hookena Bay.

the end of a rest period is often the first sign that the school as a whole is waking.

### Fluke-Outs

The *fluke-out* is a very passive pattern that we do not consider as true aerial behavior, but because the pattern is so distinctive, we mention it here. It is sometimes seen in quietly moving rest schools. An occasional animal may literally surface vertically, tail-first, thrusting the tail stock and flukes into the air before subsiding again. Such animals may emerge to about the level of the umbilicus and hold still or wriggle the tail in the air for up to 8 sec.



Tail Slaps

*Tail slaps* are slaps of the tail flukes made in either the normal or inverted position relative to the water surface (fig. 52). They produce a loud percussive noise that sometimes can be heard in air for many meters away from a school. They are sometimes given in long trains that we have termed *motorboating* because the resultant sound resembles





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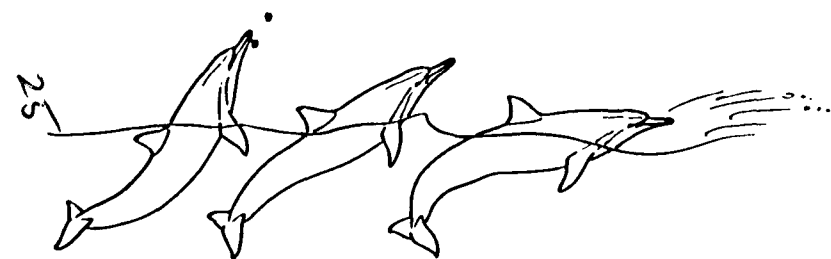


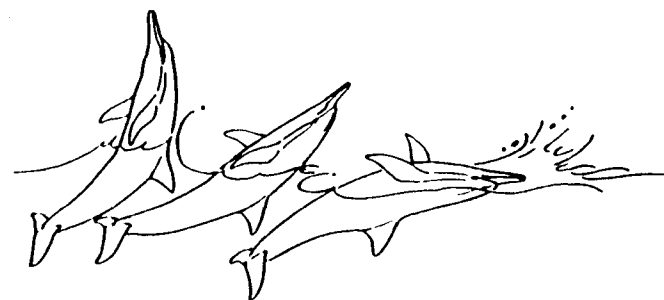
Figure 52. Top, the posture of a spinner dolphin making a tail slap; bottom, a head slap.

the noise of a very slowly moving motorboat. Some of these trains of tail slaps last for as long as 15 sec and involve 20 or more individual slaps. Motorboating by dusky dolphins has been associated with feeding. The dolphins apparently keep surface-herded fish from escaping laterally by circling around the fish school while tail slapping (Würsig and Würsig 1980).

We have observed the production of such slaps by both captive and wild dolphins with little or no forward movement involved. The animals simply rocked up and down longitudinally, their tails moving out of the water as their heads moved down. After the tail emerged, it was slapped sharply down against the water surface and the pattern was repeated. Some of the longest motorboating series we observed were made by inverted animals slapping the dorsal surface of their flukes against the water.

Single slaps are thought to have a signal function for many odontocete species, ranging from sperm whales to harbor porpoises (Norris and Prescott 1961). Such slaps may possibly signal danger, such as when a human observer disturbs a school, or they may precede synchronous dives by dolphins in a school. We saw them from our theodolite station when no human observer was near the animals.

Clearly, most tail slaps in the spinners we observed are unrelated to danger. In most cases they occur in slow-moving, undisturbed but not



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Figure 53. A back slap.

resting schools. They are often seen when behavioral state is changing. No precursor behavior has been noted.

#### *Head Slaps and Back Slaps*

As a dolphin moves slowly along, it may emerge from the water as far as about mid-body and then slap its anterior belly or back against the water. It can do this in any rotational orientation (figs. 52 and 53) creating *head slaps*, *back slaps*, and *side slaps*. These slaps are patterns of moving schools. They seem especially abundant during overall school acceleration and most frequently occur in the direction of travel. Their splash projects water forward in the direction of travel as the animal moves along.

We saw no precursor behavior to these slapping patterns underwater in dolphins in captivity. A captive dolphin performing slaps simply swam partially out of the water using rapid and very short amplitude strokes of its flukes. When one-third to about three-fourth of the dolphin's body was out of water, the animal twisted or flexed so as to strike the nearest part of its body against the water upon reentry, producing a smacking sound. To the ear, these sounds seemed much less intense than those generated by spins or tail slaps.



#### LEAPS

The impression given by all the traveling slaps discussed so far and the leaps (which follow) is that they mark the direction of movement with their elongate reentry splashes. Taken together, they allow the surface observer to form a precise instantaneous estimate of the activity level of a school. The dolphins' activity level seems to be determined by a group process, so it might be more accurate to say that, for them, such signals are likely to be related to the synchrony of behavioral state.

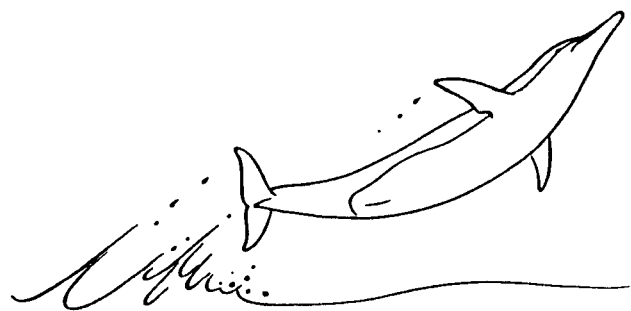


Figure 54. A salmon leap.

### Arcuate Leaps

The clean, arcing leaps made by rapidly moving dolphins (fig. 50), are called *arcuate leaps*. As in other dolphin species, they seem to relate to improving the efficiency and speed of locomotion (Au and Weihs 1980, Tui 1992). That is, by leaping, the dolphin is able to take one or two tail beats with the tail still in the water while the anterior body is in the much less dense air. This allows the animal to take advantage of the much reduced drag upon its airborne body.

Such leaps are seen in a variety of circumstances in aroused schools. Dolphins "surfing" or simply traveling in large swells often pour from the water in such leaps. A school may bound away from the source of a momentary disturbance in a series of arcuate leaps. Such a leaping school usually emerges from the water as a series of subgroups that probably represent these same formations underwater. When we have observed dolphins exiting from a rest cove in the late afternoon in a last dash to sea, locomotion typically consists of a series of arcuate leaps separated by brief periods of rapid swimming.

Unlike most other aerial patterns, arcuate leaps seem incapable of producing noise or bubbles upon reentry. Arcuate leaps are performed by dusky dolphins while they are herding fish. The dolphins come to the surface to breathe, overshoot the surface in a arcing leap, and the use of the weight of their body in the air to help propel them to depth (Würsig and Würsig 1980).

### Salmon Leaps

A more active aerial pattern is what we have termed a *salmon leap* because it looks like a salmon leaping up rapids or falls—slightly arched and stiff-bodied, usually falling back on its side. The salmon leap, which usually takes the animal completely out of water, is typically seen in fast-moving schools such as those that move out to sea after rest (fig. 54).

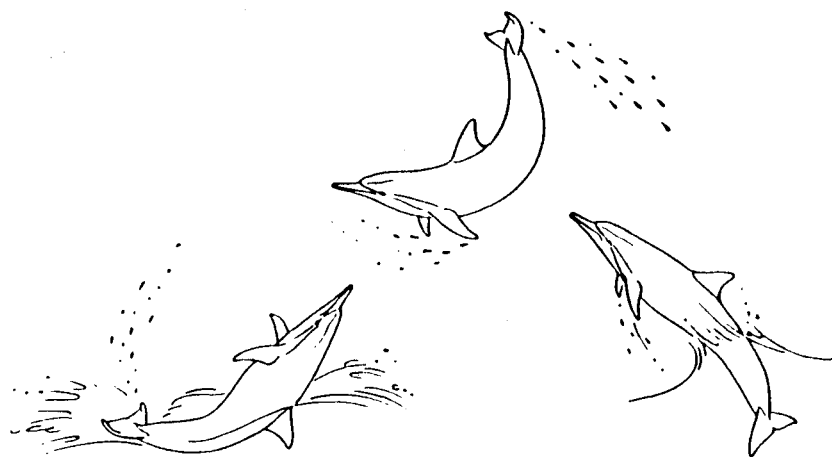


Figure 55. A tail-over-head leap.

### Tail-Over-Head Leaps

The most athletic leaps of all are the *tail-over-head leaps*. They have not been observed underwater and hence the presence or absence of precursor behavior for this pattern remains a question. In the tail-over-head leap, the animal bursts from the water in a high, arcuate leap and literally throws its tail over its head, usually accompanied by a spiraling trail of water (fig. 55). At the end of the leap, the animal slaps the dorsal surface of its flukes and body smartly against the water as it reenters tail first. Sometimes in very active schools, a dolphin will combine a spin with a tail-over-head leap and yet still contrive to make an audible slap upon reentry. Such leaps are seen by the human observer as a bewildering mélange of flashing flukes, flippers, fins, and body.



### SPINS

Spins are energetic patterns often performed in a series by a single animal (fig. 56). In one such sequence, fourteen spins in quick succession without stopping were performed by an individual. It is usual to observe sequences of four or five spins by a single animal. It is easy to tell that such a sequence is produced by a single animal because each dolphin performs the pattern somewhat individually. Some animals spin while nearly vertical, and others more nearly horizontal, reentry patterns vary, and so on. Furthermore, such sequential spinning has been observed to occur at a single general place in the school. Finally, spin series are usually performed with declining activity level. Frequently, the last attempt may fail to take the dolphin clear of the water, and it may not complete the last revolution.